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Permanent Secretary Denison Scientific Association

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The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor at $2.00 per volume, with the exception of volume 15, the price of which is $1.00. Separate parts, as listed below, may be purchased at the prices indicated.

WILLIAM CLARENCE EBAUGH, Ph. D.

Permanent Secretary—The Denison Scientific Association
Editor—*The Journal of the Scientific Laboratories of Denison University*

1925–1947

Retired from active duty—January 1, 1947.

IN APPRECIATION

On January 1, 1947 Dr. William Clarence Ebaugh, Professor Emeritus of Chemistry at Denison University, retired from active duty as Permanent Secretary of the Denison Scientific Association and Editor of the *Journal of the Scientific Laboratories of Denison University*. At the request of the Association these duties were then assumed by Dr. William Alfred Everhart, Associate Professor of Chemistry, and for many years a colleague with Dr. Ebaugh in the work of the Denison Department of Chemistry. And thus the affairs of the Journal will continue to be cared for in the same offices which have served during the twenty-two years of Dr. Ebaugh's incumbency.

During these years the publication of the Journal has been continuous, except for slight delays in the recent war years. And the distribution, mainly through exchange arrangements with other scientific associations, colleges and universities, both domestic and foreign, has been uninterrupted, except as mail service across submarine infested oceans was discontinued in war-time. Exchanges with our friends in foreign lands are being resumed in full, and missing numbers supplied, now that the international mail service is being restored. And at the present time we are pleased to list some two hundred sixty five exchange addresses, divided about equally as to domestic and foreign designation.

In appreciation of the valued services which Dr. Ebaugh has rendered to the Denison Scientific Association and to the University in his ceaseless work as Editor and Secretary of the Journal, interrupted but once, during a year's leave of absence spent abroad (1930–1931),—it was the pleasure of the Association, in regular meeting assembled on December 10, 1946, to adopt the attached resolution, a copy of which has been presented to Dr. Ebaugh.

RESOLUTION

WHEREAS: Dr. William Clarence Ebaugh, Professor of Chemistry, inspiring teacher, excellent scholar, staunch friend and loyal Denisonian, has served with distinction from January 1925 to January 1947 as Permanent Secretary of the Denison Scientific Association and as Editor of the *Journal of the Scientific Laboratories*, and has now come to the end of these supplementary duties. And whereas, it may be added, though these years were crowded with details of teaching and of administration before his duties of editorship could receive attention; yet he always maintained the highest standard for the Journal and at the same time managed to meet his own high standard. And these efforts have served to carry the name and favorable reputation of Denison University throughout the world.

Be it therefore resolved: That the Denison Scientific Association hereby

expresses its profound appreciation and gratefully acknowledges its deep indebtedness to William Clarence Ebaugh for these many years of faithful, unremunerated services and high ideals.

Furthermore be it resolved: That a copy of these resolutions be transmitted to Dr. Ebaugh, and that they be incorporated into the minutes of the Association.

Signed:
George D. Morgan, *President*
Edson C. Rupp, *Secretary*
The Denison Scientific Association
Granville, Ohio.

Adopted
December 10, 1946.

The Editor

CONODONTS FROM THE FERN GLEN OF MISSOURI

M. G. MEHL AND LEO A. THOMAS

Received March 7, 1947; published April 30, 1947

The Fern Glen formation was named and described briefly in 1906 by Stuart Weller[1] from exposures on the Meramec river at Fern Glen in St. Louis County, Missouri. He designated the fauna as "typically Kinderhook." Later Weller gave a more detailed description[2] of the formation at the type locality as follows:

5. Gray limestone with an abundance of chert; outcrops mostly covered with soil and talus upon the slope of the hill. This is the typical Burlington limestone....................Thickness, 25 feet
4. Greenish calcareous shales with an abundance of chert in bands which are more or less continuous. Toward the base the beds are somewhat variegated with the red color of the subjacent bed..........Thickness, 14 feet
3. Red calcareous shales, highly fossiliferous, with a persistent chert band at the summit 6 inches in thickness. In the midst of the bed occasional more or less continuous chert bands occur, but they are far less conspicuous than in the bed above....................Thickness, 12 feet
2. Hard, red, more or less crystalline limestone, with numerous crinoid stems and other fossils similar to those in the superjacent beds....Thickness, 14 feet
1. Hard, tough limestone, similar to that above, but of a buff color....................Exposed Thickness, 2 feet

In this section Weller designated units 2 and 3 as typical Fern Glen and stated that unit 4 "should probably be considered as part of the Fern Glen."

The lithology and color of the Fern Glen is more varied than one is led to believe from Weller's statement, "it is a highly characteristic formation, consisting of red calcareous shales which often graduate into red limestones." The relationships of the formation and, perhaps, the more typical lithology are well shown in the bluff along the Meramec river at Castlewood only a short distance above Fern Glen. The following section at Castlewood is the same as that figured by Branson.[3]

	Feet	Inches
BURLINGTON: Massive brown crinoidal limestone.		
13. Moderately bedded alternating dense gray limestone and chert bands....................	30	

[1] Stuart Weller, Kinderhook Faunal studies. IV. The Fauna of the Glen Park Limestone. Trans. Acad. Sci. St. Louis, vol. 16, p. 438, 1906.

[2] Stuart Weller, Kinderhook Faunal Studies. V. The Fauna of the Fern Glen Formation. Bull. Geol. Soc. Amer., vol. 20, p. 266, 1909.

[3] E. B. Branson, Stratigraphy and Paleontology of the Lower Mississippian, part 2, Univ. Mo. Studies, vol. 13, fig. 11, 1938.

	Feet	Inches
12. Greenish gray argillaceous limestone, scattered chert nodules and a band of "silicified stylolite"	2	
11. Greenish gray argillaceous limestone	1	3
10. Red argillaceous limestone	3	6
9. Greenish gray argillaceous limestone grading to red above	1	
8. Massive dense gray limestone	1	
7. Massive buff dense argillaceous limestone with siliceous nodules and stylolite seams	8	
6. Massive buff dense limestone with stylolite seams and siliceous nodules	3	
5. Massive buff fine grained sandstone	8	
4. Conglomerate of phosphatic pebbles		3–8
3. Black fissile shale	0–3	
2. Conglomerate of phosphatic pebbles		8
MAQUOKETA SHALE	15	
KIMMSWICK LIMESTONE		

In Branson's photographic reproduction of the above section the Maquoketa was inadvertently labeled Grassy Creek. A thickness of only about three feet immediately beneath the unit labeled Bushberg belongs to the Grassy Creek and this is reduced to nothing not many feet beyond the limits of the photograph. The part labeled Bushberg in the photograph is unit 4 and 5 of the above section, and the part labeled Fern Glen (F.G.) corresponds approximately to unit 10.

Of the section here given it is thought that units 9 to 12 inclusive are about the equivalents of Weller's 3–5. There is but slight chance that unit 10 of the present section does not correspond to Weller's unit 3 in part, and therefore, apparently represents his "typical Gern Glen."

AGE AND CORRELATION OF THE FERN GLEN

There is not a general agreement on the correlation of the Fern Glen or on the assignment of this formation and its correlatives to a major division within the Mississippian.

Weller in 1909[4] concluded that the Fern Glen is to be correlated with the non-typical upper part of the Chouteau of central Missouri and the Pierson of southwestern Missouri, resting on typical Chouteau and constituting the closing stage of the Kinderhook. To quote:

> "In sections where the Fern Glen has its typical development the limestone immediately beneath the red beds is Chouteau. . . ."

And again:

> "From the evidence presented, therefore, it is clear that while the Fern Glen may still be included in the Kinderhook as a contemporaneous formation with the highest, non-typical portion of the Chouteau limestone, it represents the closing stages of the Kinderhook, and in its fauna is foreshadowed the beginning of the succeeding life of the Lower Burlington."

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[4] Loc. Cit. pp. 322, 323.

Most subsequent writers[5] have referred the Fern Glen to the Osage group, but E. B. Branson, through his studies of the Mississippian of Missouri, concluded that it is a part of the Lower Mississippian. Branson has pointed out[6] that the term Kinderhook is not suitable for designating a division of the Mississippian because, at the type locality of the Kinderhook, units of probable Devonian age are included. He substituted the name Lower Mississippian to include all Mississippian units of pre-Burlington age. For the Burlington and following units, generally referred to the Osage, Branson designated a Middle Mississippian division.

A casual inspection of the literature also indicates a considerable disagreement in the correlation of the Fern Glen but the apparent diversity in opinion is in part a disagreement in terminology. There seems to be general agreement that the Fern Glen is older than the oldest Burlington and younger than the lower part of the Chouteau regardless of how the Chouteau is defined. The Fern Glen is considered by most writers to be the approximate equivalent of that part of the pre-Burlington of central Missouri designated by Moore as Sedalia,[7] and the Pierson of southwestern Missouri.

The name Sedalia was proposed for the siliceous dolomite of central Missouri which Swallow in 1855 designated as upper Chouteau. These beds, according to Moore, rest unconformably on various thicknesses of Chouteau (as restricted) and older formations. He states that the siliceous dolomite occupies about the same position and relationships as the Fern Glen, but in no place are his Sedalia and the Fern Glen found together. He interprets this as indicating that the two formations are at least in part time equivalents. Emphasizing an unconformity below the Sedalia and not above it, Moore considers the Sedalia and supposed equivalents, the Fern Glen of eastcentral and southeastern Missouri and the Pierson of southwestern Missouri, as initial stages of the Osage.

Branson does not accept Sedalia as a formation name[8] for a unit or units either in the Lower or Middle Mississippian. He believes that Moore's Sedalia of central Missouri is lower Burlington and that his Sedalia of southwestern Missouri is upper Chouteau, the latter without appreciable faunal differences from the typical lower Chouteau.

In Branson's Lower Mississippian he includes only the Bushberg and equivalents below and the Chouteau above. In eastcentral Missouri the Fern Glen is considered to be a member of the Chouteau formation somewhat older than

[5] E. O. Ulrich, Geol. Soc. Amer., vol. 22, pl. 29, 1911. R. C. Moore, Mo. Bureau Geol. and Mines, 2nd ser., vol. 21, fig. 2, 1928. L. M. Cline, Osage formation of southeastern Ozark Region, Missouri, Arkansas, and Oklahoma. Bull. Am. Assoc. Petr. Geol., vol. 18, no. 9, pp. 1132–1159, 1934. Frank B. Conselman, Guide Book Fifteenth Ann. Field Conference Kans. Geol. Soc., p. 12, 1941.

[6] E. B. Branson, Stratigraphy and Paleontology of the Lower Mississippian of Missouri. Univ. of Missouri Studies, vol. XIII, pt. 1, p. 5, 1938.

[7] R. C. Moore, Mo. Bur. Geol. and Mines, vol. 21, 2nd ser., p. 149, 1928.

[8] E. B. Branson, Stratigraphy and Paleontology of the Lower Mississippian, University of Missouri Studies, vol. XIII, pt. I, pp. 5, 17, and fig. 2; pt. II, pp. 48, 179, and pls. 11, 12, 1938.

the middle. In southwestern Missouri Branson's Chouteau includes the Compton, Northview, Pierson, and the Reeds Spring, in ascending order. The Reeds Spring, he believes, may represent continued deposition into the Middle Mississippian and be equivalent to the Burlington in part.

EVIDENCE OF THE CONODONTS

There are available for profitable comparison with the Fern Glen conodonts, adequate assemblages from the basal Mississippian[9] and the typical lower Chouteau[10] as developed in central Missouri. From the critical part of the section, between the lower Chouteau and the Keokuk[11] the conodont record, excepting that of the Fern Glen, is very poor. Only a few specimens have been found in the non-typical upper Chouteau and little material from the Burlington is available. The senior writer has studied somewhat more extensive collections from the Pierson and Reeds Spring of southwestern Missouri. An apparently representative assemblage of conodonts from the Weldon limestone of Oklahoma[12] is available and would be very useful if its age were less uncertain.

The recorded fauna of the lower Chouteau is distributed in thirteen genera, two less than are listed in the following pages from the Fern Glen. The two faunas have ten genera in common. Three genera are found in the Chouteau and not in the Fern Glen, *Spathognathodus*, *Solenodella*, and *Siphonodella*. The first genus is known to range from the early Silurian to the end of the Paleozoic and its absence from the Fern Glen has little meaning unless it is to emphasize the inadequacy of the record. The absence of the other two genera from the Fern Glen may have no greater significance, but it should be noted that *Solenodella* and *Siphonodella* appear in the basal Mississippian (Bushberg and Hannibal) but have not been identified in any formation of an age proven younger than Fern Glen. Their presence in the Welden noted by Taylor[13] raises the question of their upward range.

The five genera listed for the Fern Glen and not recorded in the lower Chouteau are *Bactrognathus*, *Metalonchodina*, *Palmatodella*, *Prioniodina*, and *Pseudopolygnathus*. Two of these, *Prioniodina* and *Palmatodella*, are of little value in this comparative study. The first is identified with question and the second is based on a single species and specimen that might well be overlooked in a collec-

[9] E. B. Branson and M. G. Mehl, Conodonts from the Bushberg sandstone and equivalent formations of Missouri, Univ. of Missouri Studies, vol. VIII, No. 4, pp. 265–299, pls. 22–24, 1933. E. R. Branson, Conodonts from the Hannibal formation of Missouri, Univ. of Missouri studies, Vol. VIII, No. 4, pp. 301–334, pls. 25–28, 1933.

[10] E. B. Branson and M. G. Mehl, Conodonts from the Lower Mississippian of Missouri, Univ. of Missouri Studies, vol. XIII, No. 4, pp. 134–148, pl. 34, 1938. C. L. Cooper, Conodonts from a Bushberg-Hannibal Horizon in Oklahoma, Jour. Pal., vol. XIII, No. 4, pp. 379–422, pls. 39–48, 1939.

[11] E. B. Branson and M. G. Mehl, Conodonts from the Keokuk Formation, Denison Univ. Bull., Jour. Sci. Labs., vol. XXXV, pp. 179–188, pl. VI, 1940.

[12] Louis Taylor, The conodonts and age of the Weldon Limestone. Unpublished Master's Thesis, University of Missouri, 1941.

[13] Op. Cit.

tion of poorly preserved material from other formations. The genera *Metalonchodina* and *Bactrognathus* suggest that the Fern Glen fauna is younger than that of the typical (lower) Chouteau. Neither is recorded in formations proven to be older than Fern Glen. Some of the specimens from the sub-Welden clay, referred to *Lonchodina* by Cooper, possibly should be referred to *Metalonchodina*.[14] Cooper designated this clay as Bushberg-Hannibal but the age has been questioned.[15] *Metalonchodina* is abundantly represented in later Mississippian formations and throughout the Pennsylvanian. *Bactrognathus* occurs in the Pierson and the Reeds Spring with later range uncertain. It is not recorded in the Keokuk or later Mississippian.

The presence of *Pseudopolygnathus* in the Fern Glen and its absence in typical Chouteau is not readily explained. Although the Fern Glen development is not typical of the genus there can be only very slight doubt of the correctness of the identification. There are four species recognized, each represented by many good specimens. The genus is well represented in the basal Mississippian.

A comparison of conodont faunas by specific analysis is always unsatisfactory. All investigators recognize that ideas concerning specific characters are still confused and that only a small percentage of the species named can be identified with certainty by all competent workers. However, the differences between the Fern Glen and typical Chouteau faunas are so conspicuous that they deserve listing although strong support of any particular interpretation is not justified. Of the 33 species listed for the Fern Glen only three are found in the Chouteau (restricted). *Polygnathus communis* apparently ranges from basal Mississippian (Bushberg) into middle Mississippian. *Prioniodus corniger* is recorded in the Hannibal as well as in the Fern Glen and lower Chouteau. *Gnathodus perplexus*, the third species held in common, ranges into upper Mississippian.

It may be argued that the marked differences between the typical Chouteau conodonts and those of the Fern Glen bespeak a facies development reflecting special Fern Glen conditions although only limited response of conodonts to environment has been noted. It is obvious that a knowledge of Burlington conodonts is needed before the Fern Glen assemblage can be evaluated properly.

THE CONODONT FAUNA

Conodonts are not abundant in the Fern Glen and an adequate picture of the assemblage has required their segregation from a large number of samples. This sampling indicates that there is a very patchy distribution of specimens both in numbers and kinds. Some of the samples were nearly barren and others produced with fair abundance. Several samples produced a considerable number of specimens of the same species almost to the exclusion of other forms. In nearly all samples, specimens of *Pseudopolygnathus* and *Polygnathus communis* were abundant. None of the samples produced more than a very few specimens of *Hindeodella*. One of the surprising features of the fauna is the absence of repre-

[14] Cooper, C. L. Jour. Paleo. vol. 13, pl. 47, figs. 50 and 51.

[15] E. B. Branson and M. G. Mehl. The Recognition and Interpretation of mixed Conodont Faunas. Denison Univ. Bull. Jour. Sci. Laboratories, Vol. XXXV Dec. 1940, p. 204.

sentatives of the genus *Siphonodella* which is moderately represented in the Welden, a formation apparently younger than the Fern Glen.

DETAILS OF THE FAUNA

It is recognized that an abnormally large number or fragmentary specimens has been utilized as types in the descriptions that follow. The producing zones are sufficiently argillaceous to have permitted considerable compression of the sediments and complete specimens, except for more massive forms, are not to be expected. The complete fauna would probably include a fourth or a third more species that have been omitted because materials representing them are even more fragmentary and less certain in their distinctive features.

COLLECTING LOCALITIES

The Fern Glen has produced conodonts in some abundance from several widely separated localities. In Ste. Genevieve County, Missouri, nearly every outcrop sampled has produced a few specimens. In all of these collections no important differences have been noted except that of relative abundance. However, inasmuch as the exact horizon of most of these collections is not certain only the conodonts from one locality have been described in the following pages. This collection, designated as from the Castlewood locality, came from the units 9, 10, and 11 of the section described above. Very careful zonal collection from bottom to top of each of these units failed to bring out important differences; and it is assumed that the collection here described constitutes a faunal group characteristic of the stratigraphic units here mentioned.

Genus BRACTROGNATHUS Branson and Mehl

Plate 1, Figure 15

Bactrognathus sigmoides Mehl and Thomas, n. sp.

Thin, blade like, slightly arched; sigmoid in oral view; postero-lateral extension long, flexed downward about 10 degrees, laterally flexed about 50 degrees. Oral edge consisting of about 12 laterally compressed sub-equal denticles with a tendency to increase in size to the major one located just back of the apical pit; all with confluent bases and discrete apices, slightly flexed outward and inclined posteriorly. Aboral edge thin throughout its length except at the apical pit located slightly back of mid-length. Pit sub-elliptical with anterior and posterior groove extending a short distance.

Holotype.—Univ. Missouri, C656-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Bactrognathus recta Mehl and Thomas, n. sp.

Plate 1, Figure 11

Thin, bar like, main axis straight in oral and lateral views; postero-lateral extension short, downward and laterally flexed about 10 degrees, more blade-like than main axis. Carina consisting of about 13 laterally compressed sharp-pointed and sharp edged denticles, with confluent edges but discrete apices, all

are inclined posteriorly. Denticles sub-equal, first two large, with the following smaller denticles tending to increase in size to a superior one located over the apical pit. Denticles on the main axis erect, those on the postero-lateral extension flexed toward the inner side. Aboral edge thin with a large apical pit located approximately three-fourths the length of the bar from the anterior end. Pit with thin sharp, laterally flaring extensions that remain discrete to the anterior end.

Holotype.—Univ. Missouri, C655-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Bactrognathus perplana Mehl and Thomas, n. sp.

Plate 1, Figure 12

Thin, bar like, with main axis straight in oral and lateral views; postero-lateral extension short, downward and laterally flexed approximately 45 degrees, more blade-like than main axis. Axis consisting of about 10 laterally compressed coalesced denticles that constitute a continuous carina, with only low nodes to show the position of the denticles. Denticles sub-equal with a tendency to increase in size to the superior one located over apical pit. Aboral edge wide; apical pit large, approximately three-fourths the length of the bar from its anterior end. Anterior extension of pit wide, deeply excavated with lateral margins set off from the bar by thin sharp edges; posterior extension of pit a faint groove extending the length of the blade.

Holotype.—Univ. Missouri, C655-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Bactrognathus multidentata Mehl and Thomas, n. sp.

Plate 1, Figure 13

Thin, bar like; main axis straight in oral and lateral views; postero-lateral extension short, slightly flexed downward, straight in oral view. Carina consisting of about 18 erect, laterally compressed sharp-pointed and sharp edged denticles, all with confluent edges but discrete apices. Denticles sub-equal, the first few long, those following smaller, with a tendency to increase in size to the superior one located over the apical pit. Aboral edge moderately wide, deeply excavated, with a large apical pit near the posterior end. Pit with thin sharp flaring lateral margins that extend along the bar to its anterior and posterior extremities.

Holotype.—Univ. Missouri, C655-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus BRYANTODUS Ulrich and Bassler

Bryantodus (?) sp. indet.

Plate 1, Figure 39

This broken, massive specimen, questionably referred to Bryantodus, is the only specimen found in the Fern Glen that might represent this genus.

Figured specimen.—Univ. Missouri, C655-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus GNATHODUS Pander

Gnathodus texanus (Roundy)

Plate 1, Figure 3

1926. *Polygnathus texanus* Roundy. U. S. Geol. Survey Prof. Paper 146, p. 12, pl. II, figs. 7a–8b.
1940. *Gnathodus texanus* Roundy. Branson and Mehl. Denison Univ. Bull. Jour. Sci. Labs., vol. 25, p. 173, pl. V, figs. 23–25.

Specimens referable to this species are found abundantly in the Fern Glen.

Figured specimen.—Univ. Missouri, C655-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Gnathodus perplexus Branson and Mehl

Plate 1, Figure 4

1938. *Gnathodus perplexus* Branson and Mehl. Missouri Univ. Studies, vol. 13, no. 4, pt. 2, p. 145, pl. 34, fig. 24.
1939. *Gnathodus perplexus* Branson and Mehl. C. L. Cooper, Jour. Pal., vol. 13, p. 388, pl. 42, figs. 47–50.

Fern Glen specimens of this species show little difference from those in the Chouteau.

Figured specimen.—Univ. Missouri, C654-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Gnathodus cuneiformis Mehl and Thomas, n. sp.

Plate 1, Figure 2

Axis nearly straight, but slightly curved laterally near posterior end. Blade comparatively thick, edged with laterally compressed sub-equal denticles, with short free apices. Carina slightly elevated, consisting of a nodose ridge, oral edge down curved at its posterior end to meet the aboral outline, extending beyond posterior end of plate. Cup large, longer than wide, greatest diameter at anterior end and slightly diagonal to axis. Outer margins of oral surface marked by elevated, slightly nodose ridges that nearly parallel the carina. The elevated outer margins form a moderately deep depression on each side of the carina.

Holotype.—Univ. Missouri, C654-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus HINDEODELLA Ulrich and Bassler

Hindeodella sp. indet.

Plate 1, Figure 1

A small number of specimens in our collections from the Fern Glen indicates the presence of at least one species referable to the genus *Hindeodella*. None of these specimens is sufficiently complete to justify specific description.

Figured specimen.—Univ. Missouri, C654-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus LIGONODINA Ulrich and Bassler

Ligonodina grandicula Mehl and Thomas, n. sp.

Plate 1, Figure 35

Terminal fang large, flexed posteriorly about 45 degrees just above the base; circular at base and planoconvex above flexure, with the plane side posterior, much compressed antero-posteriorly near the apex. Both posterior and lateral bars aborted, bearing circular denticles. Apical pit large, elongated posteriorly and extending as an excavation under bar. Outer anterior face of fang produced to form a long aboral projection.

Holotype.—Univ. Missouri, C654-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Ligonodina curvidens Mehl and Thomas, n. sp.

Plate 1, Figure 25

Terminal fang moderately long, strongly recurved, subcircular in cross section at base, becoming laterally compressed toward the apex, lateral faces rounded; anterior face marked by a faint ridge which extends from the apex of fang to the oral surface of the antero-inferior flexure; posterior face marked by small straight ridge. Antero-inferior process short, delicate, bearing discrete denticles that are circular in cross section, and flexed inward. Posterior bar short, delicate, consisting of a posterior extension of the base of the terminal fang; bearing small discrete denticles. Aboral edge flat to broadly excavated. Apical pit antero-posteriorly elongate, extending as an excavation under bars.

Holotype.—Univ. Missouri, C654-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Ligonodina compressa Mehl and Thomas, n. sp.

Plate 1, Figure 31

Terminal fang moderately long, recurved, laterally compressed with sharp anterior and posterior edges, lateral faces slightly rounded. Antero-inferior process short, blade-like, about three times as deep as thick, bearing laterally compressed, fused denticles. Posterior process short, blade-like, about twice as deep as thick, bearing laterally compressed fused denticles. Aboral edge narrow. Apical pit moderately deep, elongate, extending to extremities of processes as a groove.

Holotype.—Univ. Missouri, C653-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Ligonodina (?) *minuta* Mehl and Thomas, n. sp.

Plate 1, Figure 27

Terminal fang long, thin, erect, laterally compressed with sharp anterior and posterior edges, lateral faces slightly rounded. Antero-inferior process short, blade-like, about twice as deep as broad, flexed inward about 15 degrees, bearing discrete, laterally compressed, sharp edged denticles. Posterior process short, blade-like, less than twice as deep as broad, bearing laterally compressed, sharp

edged denticles with confluent bases and probably discrete apices. Aboral edge narrow; apical pit deep, elongate, extending to extremities of the processes as a moderately deep excavation.

Holotype.—Univ. Missouri, C653-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Ligonodina subclavata Mehl and Thomas, n. sp.

Plate 1, Figure 26

Terminal fang long, straight, inclined slightly backward, sub-circular in cross section with moderately sharp anterior and posterior ridges, greatly thickened at base. Antero-inferior process short, blade-like, slightly less than twice as deep as broad, flexed inward about 35 degrees, bearing discrete, laterally compressed, sharp-edged denticles with confluent bases and probably with discrete apices. Posterior process short, bar like, about equal height and width; denticles discrete, sub-circular in cross section. Aboral edge broadly excavated, outer anterior flare projecting downward; apical pit deep, elongate, extending under processes as a groove.

Holotype.—Univ. Missouri, C653-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Ligonodina ortha (Cooper)

Plate 1, Figure 34

1939. *Neocordylodus orthus* Cooper. Jour. Pal., vol. 13, p. 396, pl. 47, figs. 4, 14.

Specimens from the Fern Glen were found to be con-specific with those described from the sub-Welden by Cooper.

Figured specimen.—Univ. Missouri, C653-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus LONCHODINA Ulrich and Bassler

Lonchodina minuta Mehl and Thomas, n. sp.

Plate 1, Figure 20

Base thin, highly arched, with marked lateral offset of the arch just behind the apical pit. Aboral edge flat, with a faint median groove extending the length of each limb from an elongate, large apical pit. Denticles of limbs small, discrete, subcircular in cross section, flexed slightly inward. Apical denticle long, strongly recurved, sub-circular with base produced into a flare over apical pit.

Holotype.—Univ. Missouri, C653-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Lonchodina (?) *serrata* Mehl and Thomas, n. sp.

Plate 1, Figure 22

A moderately arched blade with anterior limb about twice as deep as broad, bearing at least four laterally compressed, discrete, sub-equal, sharp-edged denticles, all inclined slightly posteriorly. Posterior limb set off and similar to anterior limb. Superior denticle (broken in figured specimen) laterally com-

pressed, flexed inward, located over apical pit. Aboral edge thin. Apical pit round and extending to extremities of limbs as a small groove.

Holotype.—Univ. Missouri, C652-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Lonchodina (?) *excavata* Mehl and Thomas, n. sp.

Plate 1, Figure 33

Moderately arched bar with anterior limb forming an angle of 90 degrees with posterior limb in oral view. Anterior limb massive, sub-rounded with truncated base and moderately narrow oral edge, bearing large discrete circular sub-equal denticles. Posterior limb formed by an extension of the base of the fang, smaller than anterior limb, bearing small circular denticles. Apical denticle large, recurved, sub-circular, base flared. Each limb giving rise to a small ridge that extends to the apex of the denticle. Aboral edge broad; apical pit deep, elongate in line with the anterior limb, extending under both limbs as a moderate excavation.

Holotype.—Univ. Missouri, C652-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Lonchodina discreta Ulrich and Bassler

Plate 1, Figure 16

1926. *Lonchodina discreta* Ulrich and Bassler. U. S. Nat. Mus. Proc. vol. 68, art. 12, p. 36, pl. 10, fig. 1, 2.

1928. *Lonchodina discreta* Ulrich and Bassler. Holmes, U. S. Nat. Mus. Proc. vol. 72, art. 5, p. 26, pl. 9, fig. 13.

1935. *Lonchodina discreta* Ulrich and Bassler. C. L. Cooper, Jour. Pal. vol. 9, p. 310, pl. 27, fig. 21.

1939. *Lonchodina discreta* Ulrich and Bassler. C. L. Cooper, Jour. Pal. vol. 13, p. 391, pl. 47, fig. 50, 51, 71, 72.

A small number of specimens from the Fern Glen appear to be identical with the development of this species as found in the sub-Welden of Oklahoma.

Figured specimen.—Univ. Missouri, C652-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus METALONCHODINA Branson and Mehl

Metalonchodina acutirostris Mehl and Thomas, n. sp.

Plate 1, Figure 21

Strongly arched; posterior bar thin, about as thick as broad, denticles discrete, unequal in size, the one over the pit the largest, circular in section, curved slightly outward in superior view. Anterior bar thin, laterally compressed, pointed, bearing one compressed sharp edged denticle. Base of denticle over attachment scar flaring into an apron. Anterior bar forming an angle of about 160 degrees with posterior bar. Aboral edge broad, apical pit deep, elongate, extending under process as a groove.

Holotype.—Univ. Missouri, C659-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Metalonchodina alternata Mehl and Thomas, n. sp.

Plate 1, Figure 19

Unit broadly arched; bar about as thick as broad, denticles discrete, major set alternates in position with a minor set, the one over the pit the smaller of the two major ones. Denticles slightly compressed, very moderately curved inward in superior view. Minor denticles of anterior bar curved outward giving the unit a sigmoid appearance. Inner base of denticle over attachment pit flaring into an apron, outer edge straight. Aboral edge broad, apical pit deep, triangular in outline and confined to the inner margin of the bar, extending along processes as a groove.

Holotype.—Univ. Missouri, C652-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus OZARKODINA Branson and Mehl

Ozarkodina sp.

Plate 1, Figure 7

A slightly arched blade, nearly straight in oral view, somewhat deeper than wide. Anterior limb bearing about eight laterally compressed sharp edged denticles, all with confluent bases and discrete apices, sub-equal with a tendency toward increase in size to the superior denticle located over the apical pit, all inclined posteriorly. Superior denticle laterally compressed, about twice as thick as limb denticles. Posterior limb bearing at least four laterally compressed denticles of irregular size, with confluent bases and probably discrete apices. Posterior end of posterior limb flexed laterally. Aboral edge thin; apical pit elongate antero-posteriorly, extending along aboral edge a short distance as a groove.

Figured specimen.—Univ. Missouri, C659-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus PALMATODELLA Ulrich and Bassler

Palmatodella triangularis Mehl and Thomas, n. sp.

Plate 1, figure 6

A unit consisting primarily of a large incurved denticle with sub-triangular base and sub-circular above. Base flared to produce an apron covering apical pit, lateral margins sharply produced to form anterior and posterior blades, inner face round. Posterior blade short, non-denticulate, extending high on the major denticle. Anterior blade similar to posterior limb but bearing several minute, completely fused denticles that can be seen only in transmitted light. The two limbs form an angle of about 80 degrees. Aboral edge thin; apical pit deep, sub-triangular, extending on limbs as a faint groove.

Holotype.—Univ. Missouri, C659-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus POLYGNATHUS Hinde

Polygnathus arcuata Mehl and Thomas n. sp.

Plate 1, Figure 38

Plate nearly bilaterally symmetrical, twice as long as wide, arched anteroposteriorly in lateral view, sharply pointed on the posterior end, widest near the front. Lateral margins of plate curved oral except at the back where they are flexed downward and nearly normal to the carina. Outer margins marked by low nodes that extend to the carina as straight, rather indistinct ridges. Carina not greatly elevated, convex in lateral view and marked by low nodes, rising gradually from the back to attain greatest height at the front end. Aboral surface rounded to the lateral margins. Keel high and sharp on the posterior end of the plate, decreasing to flat and broad at the anterior end. Pit small, fusiform, extending as a groove a short distance along keel. Blade unknown.

Holotype.—Univ. Missouri, C659-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Polygnathus communis Branson and Mehl

Plate 1, Figure 37

1933. *Polygnathus communis* Branson and Mehl. Univ. Missouri Studies, vol. 8, no. 4, p. 293, pl. 24, fig. 5–7.

1933. *Polygnathus communis* Branson and Mehl. E. R. Branson, Univ. Missouri Studies, vol. 8, no. 4, p. 308, pl. 25, figs. 5, 6.

1938. *Polygnathus communis* Branson and Mehl. Univ. Missouri Studies, vol. 13, no. 4, pt. 2, p. 145, pl. 34, fig. 38-41, pl. 33, fig. 55.

1939. *Polygnathus communis* Branson and Mehl. C. L. Cooper, Jour. Pal., vol. 13, p. 399, pl. 39, figs. 1, 2, 9, 10, 23, 24.

This species is abundantly represented in the Fern Glen by specimens that average somewhat larger than the type from the Bushberg sandstone of Missouri and are more pointed.

Figured specimen.—Univ. Missouri, C658-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus PRIONIODINA Ulrich and Bassler

Prioniodina (?), sp. indet.

Plate 1, Figure 14

A very small number of specimens in our collections from the Fern Glen indicates the presence of at least one species to be referred with question to the genus *Prioniodina.* None of these specimens is sufficiently complete to justify specific description.

Figured specimen.—Univ. Missouri, C658-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus PRIONIODUS Pander

Prioniodus compressus Mehl and Thomas, n. sp.

Plate 1, Figure 24

Terminal fang about three times as wide as bar denticles and more than twice as long, much compressed with sharp anterior and posterior edges, vertically concave on the inner side and somewhat inclined posteriorly. Lateral faces slightly rounded near the apex and much swollen at the greatly flared inner basal

edge. Anterior projection short and thin. Apical pit moderately deep, subtriangular in outline, located back of the median line of the fang and toward its inner side, pit extending into anterior and posterior projections as a moderately deep excavation. Posterior bar thin, bearing compressed fused denticles that are inclined inward.

Holotype.—Univ. Missouri, C658-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Prioniodus corniger, E. R. Branson

1933. *Prioniodus corniger*, E. R. Branson. Univ. Missouri Studies, vol. 8, no. 4, p. 329, pl. 28, fig. 2.

1938. *Prioniodus corniger*, E. R. Branson. Branson and Mehl, Univ. Missouri Studies, vol. 13, no. 4, p. 143, pl. 34, fig. 19.

Plate 1, Figure 23

This species is found sparingly represented in the Fern Glen.

Figured specimen.—Univ. Missouri, C659-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Prioniodus sp.

Plate 1, Figure 29

Unit small, delicate, regularly curved inward. Oral blade thin, slightly arched in lateral view. Denticles of blade small, sub-equal in length, laterally compressed, fused except for short free apices. Terminal fang large, slightly flattened laterally with small but distinct sharp edges, regularly curved inward from base to tip, aboral extension short, compressed with rounded extremity, base moderately and equally expanded into thin lips overhanging a large pit elongated to include the aboral projection and a portion of the blade.

Remarks.—This form is distinctive, but because it is represented by a single specimen and because of the possibility that it is immature a specific name does not seem justifiable at this time.

Figured specimen.—Univ. Missouri, C658-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus PSEUDOPOLYGNATHUS Branson and Mehl

Pseudopolygnathus multistriata Mehl and Thomas, n. sp.

Plate 1, Figure 36

Plate of medium thickness canoe-shaped, widest near mid-length, slightly more than twice as long as wide, axis slightly curved laterally. Each platform marked by about eleven transverse ridges that fail to reach the carina or by elongate nodes that are confined to the outer margin of the plate. Carina low, roughened by low blunt nodes, rising from the posterior end of plate. Aboral surface transversely convex, bearing ridges and furrows that correspond to similar features of the oral surface. Navel of medium size, sub-circular with short anterior and long posterior groove extensions outlined by rounded elevated margins.

Holotype.—Univ. Missouri, C657-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Pseudopolygnathus attenuata Mehl and Thomas, n. sp.

Plate 1, Figure 9

Plate of medium thickness, narrow, about twice as long as wide, straight in lateral and oral views, widest at the front, narrowing posteriorly, continued posteriorly beyond the plate proper as combined carina and keel. Each platform marked by three or four widely spaced sharp transverse ridges that extend to the carina, summits of ridges and carina at nearly the same level. Carina low, rising from the posterior end toward the front, roughened by low nodes. Blade thin with sharp oral and aboral edges, oral edge with indistinct crenulations. Aboral side smooth, navel large, elliptical with margins sharp and elevated, extended anteriorly and posteriorly along keel.

Holotype.—Univ. Missouri, C658-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Pseudopolygnathus rustica Mehl and Thomas, n. sp.

Plate 1, Figure 8

Plate of medium thickness, about two and a half times as long as wide, axis curved laterally, widest at the front, narrowing posteriorly. Each platform marked by eight to twelve coalesced nodes that are confined to the outer margins. Carina low, rising gradually from the posterior end, composed of fused denticles. Aboral surface smooth but faintly marked by depressions and ridges that correspond to similar features of the oral surface. Navel large, sub-elliptical, most rounded at the anterior end, extended posteriorly and anteriorly along the keel as a slight groove, margins rounded and elevated.

Holotype.—Univ. Missouri, C657-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Pseudopolygnathus striata Mehl and Thomas, n. sp.

Plate 1, Figure 10

Plate thick, canoe-shaped in oral view, axis straight, lateral margins irregular. Margins of oral surface marked by short thick sharp nodes, about six on one side and eight on the other, smaller and discrete toward the extremities of plate, extending to the carina elsewhere. Carina low, slightly nodose, most prominent anteriorly. Aboral side sharply keeled. Shallow sub-circular navel extending anteriorly and posteriorly as a faint groove.

Holotype.—Univ. Missouri, C657-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus SUBBRYANTODUS Branson and Mehl

Subbryantodus macer Mehl and Thomas, n. sp.

Plate 1, Figure 5

Bar thin, about twice as deep as thick, highly arched with a moderate flexure at the apex, posterior limb about twice as long as anterior limb, arch as a whole

curved laterally with moderate concavity on the inner side. Denticles of anterior limb about six, much compressed laterally with sharp edges in contact to near the apices, irregular in length, all somewhat recurved and inclined posteriorly. Apical denticle laterally compressed with sharp edges, longer and slightly less than twice as wide as the largest of the limb denticles, slightly recurved, forming a right angle with the posterior limb. Denticles of posterior limb three or more, sub-equal, partially fused, almost erect. Apical pit deep, with a slight flare of the outer margin, much elongate and extended as a groove to the limb termini.

Holotype.—Univ. Missouri, C657-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

Genus TRICHOGNATHUS Branson and Mehl

Trichognathus dubia Mehl and Thomas, n. sp.

Plate 1, Figure 17

Limbs of arch delicate, aborted, sub-circular, bearing small compressed sharp edged denticles that are partially fused to the base of the fang. Apical denticle moderately long, strongly recurved, sub-circular, each lateral face marked by a faint ridge that extends from the apex and connects with the arch limbs, anterior and posterior faces rounded. Posterior limb short, non-denticulate, little more than an extension of the flaring base of the fang. Apical pit deep, large, sub-circular, extending along flattened limbs as a groove.

Holotype.—Univ. Missouri, C656-3.

Occurrence.—Fern Glen, Castlewood, Missouri.

Trichognathus delicata Mehl and Thomas, n. sp.

Plate 1, Figure 30

Limbs of arch delicate, short, sub-triangular with wide aboral edge, forming an acute angle, denticles discrete, circular, curved posteriorly. Apical denticle long, slender, curved posteriorly, triangular in section at base and becoming circular near apex, each lateral and the posterior face marked by a faint ridge that extends to the bars, anterior face rounded. Posterior bar moderately long, sub-triangular. Apical pit deep, sub-triangular with grooves extending the length of the bars.

Holotype.—Univ. Missouri, C657-1.

Occurrence.—Fern Glen, Castlewood, Missouri.

Trichognathus macroda (Cooper)

Plate 1, Figure 32

1939. *Neocordylodus macrodus* Cooper. Jour. Pal., vol. 13, p. 397, pl. 46, fig. 62 (not pl. 47, fig. 12).

Comparison of the Fern Glen representatives with specimens from the sub-Welden shows them to be conspecific.

Figured specimen.—Univ. Missouri, C656-5.

Occurrence.—Fern Glen, Castlewood, Missouri.

Trichognathus c.f. *apla* (Cooper)

Plate 1, Figure 28

1939. *Telumodina apalus* Cooper. Jour. Pal., vol. 13, p. 421, pl. 47, fig. 37.

A small number of specimens representing this species is found in the Fern Glen. These specimens compare favorably with representatives from the sub-Welden.

Figured specimen.—Univ. Missouri, C656-4.

Occurrence.—Fern Glen, Castlewood, Missouri.

Trichognathus sp.

Plate 1, Figure 18

Limbs of arch delicate, aborted, sub-circular, forming an angle of about 35 degrees. Denticles sub-circular, discrete. Apical denticle long, strongly recurved, circular in section, base triangular in section and flared, each lateral face marked by a faint but distinct ridge that originates in a small depression at the base and extends the length of the fang, anterior face rounded, posterior face marked by a small depression that is most pronounced in the lower half of the length of the fang. Posterior bar of moderate length, sub-circular, denticles circular in section. Apical pit deep, sub-triangular, extending as a distinct excavation on the limbs and bar.

Figured specimen.—Univ. Missouri, C656-2.

Occurrence.—Fern Glen, Castlewood, Missouri.

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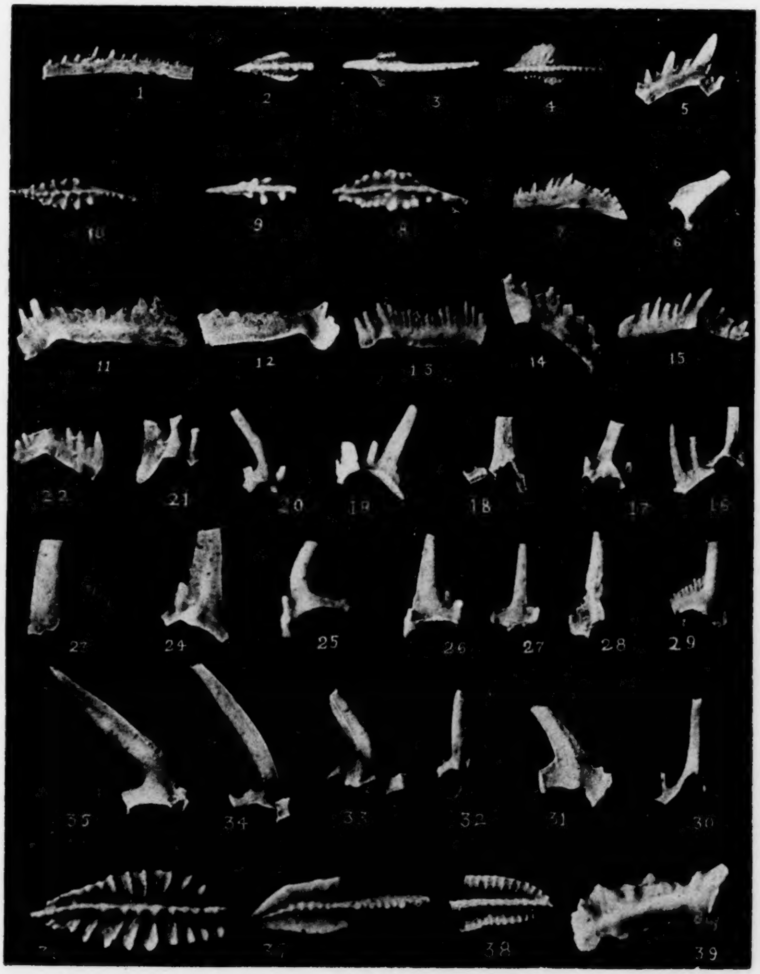

MEHL AND THOMAS FERN GLEN CONODONTS

WHERE DO WE STAND WITH CANCER?*

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When the speaker was asked to choose a medical subject which he thought might be of general interest to the Denison Scientific Association, he chose the subject of cancer because he could think of no human illness which is of greater interest to the scientist or of more concern to the general public.

Scientific research has constantly improved our medical knowledge of numerous diseases; and it is understandable that this has had a direct effect upon the comparative standings of the various diseases as a cause of death. Tuberculosis, typhoid fever, diphtheria, smallpox and nutritional diseases at one time ranked high and took a heavy toll. Although no specific treatment for tuberculosis had been developed, until streptomycin came into use in 1946, a continuous campaign of education and investigation has dropped this dread disease to a much lower level. Improved sanitation has done the same for typhoid. Improved knowledge of immunology with widespread vaccination and inoculation of our children has caused a marked decrease in the incidence of smallpox and diphtheria. Due to the great speed-up in our mode of living and due to the fact that the average span of life is now longer, heart disease has now risen to first place as a cause of death. Cancer is second only to heart disease. In fact, Dr. E. B. Wilson of the Harvard Public Health Service has recently proved, conclusively, that in women, between the ages of 35 and 55, cancer is the leading cause of death. Every three minutes, in the U. S., someone dies of cancer. There are now seventeen million people living in this country who are doomed to die of cancer unless we can do something about it. It is realized that statistics are not interesting, but a few examples may be cited merely to illustrate what is happening. In 1938 there were recorded, in this country, 149,000 deaths from cancer. Unless prevailing conditions are greatly improved we know that the outlook for the future is even worse; and it has been estimated that 200,000 people will die of cancer in 1950. It is reported that in the time from Pearl Harbor to V-J day, this country lost 280,000 lives in the shooting war. During the same period, we lost 607,000 lives from cancer. This same trend exists in the reports from other countries. No age group, not even children, is immune.

These appalling figures are given in order to indicate the basis of the present national campaign against this great killer. Can we do something about it? It would be encouraging to answer this with a strong affirmative! It isn't that easy, however. So much has been written about cancer in the past few years

* Read before an open meeting of the Denison Scientific Association at Granville, Ohio, on February 25, 1947.

that it is difficult to separate the near facts from the true facts, so that a clear analysis can be made as to our progress and our achievements. This country spent over two billion dollars in constructing the first atomic bomb. More than one hundred thousand workers, including the nation's leading scientists, military minds and industrialists teamed up to accomplish this impossible task in two and one half years. While we were spending three hundred seventeen billion dollars on the war, we were spending only two million dollars on the war against the disease that produced more than twice the number of casualties.

There can be little doubt but that the country has at last become cancer conscious. The American Cancer Society, after carrying on educational campaigns for the past thirty years, has now organized for a full scale attack. Local societies have been organized in almost every city. Funds are being raised in much the same manner as they were raised in the tuberculosis campaign. Our Federal government has set up a National Foundation of Cancer Research to correlate the work of the various cancer societies. At the present time, fourteen of our forty-eight states have full time divisions of cancer control. Fellowships have been established so that young scientists and qualified doctors can devote their full time to this campaign. A field army of more than 250,000 women has been taught the fundamentals of the biology of cancer and this great army has been carrying on an extensive educational campaign. They have also made it possible to encourage and initiate legislation for cancer control. Cancer biology has been introduced into our public schools. A small textbook "Youth Looks at Cancer" is being used in the biology department of many high schools. The University of Texas has set up, at Houston, a hospital for cancer research. The University of Minnesota has established an institute of cancer biology and is, by the way, the first institute in the world to offer a doctorate in cancer biology. The Hahnemann Medical College in Philadelphia has a full time department of cancer. The Sloane-Kettering Institute has been set up and financed to work with the greatly enlarged Memorial Cancer Hospital in New York. These are but a few of the many examples that could be cited.

Even in our Veteran's Administration great concern has been shown about the steady increase in the population of cancer patients in Veterans Hospitals.. This now totals 1500; and by the time the veterans of the recent war reach the age of high cancer incidence, about twenty years from now, it is estimated that at least 5,000 beds will be needed for cancer patients alone.

There have been numerous conferences held in recent years dealing with the various aspects of the cancer problem; and these have shown an increasing interest in the coordination and integration of cancer research on a national scale. When the first conference was held on gastric cancer in 1940, it was the first time that the laboratory worker was brought together with the surgeon, the radiologist, and the pathologist to exchange ideas and experiences and to develop plans for cooperative research. Such conferences have also been held on endocrines, genetics, and other subjects. And these conferences have pointed out the need for closer cooperation between those working with experimental animals and those working with human cancer. In the future, there will be other conferences

on the role of radio-biology in cancer, the cytology of the cancer cell, nutrition in relation to cancer and other phases of the problem.

The National Cancer Institute has also set up a repository for various inbred strains of laboratory animals and numerous transplantable animal cancers. These essential biologic tools have been made available to all workers free of charge.

This should make it clear that the attack on the cancer problem requires the combined efforts of many men trained in many different branches of biology, chemistry and physics. It is no longer possible for the individual to work alone. Although it is important that he maintain his individual imagination and initiative, he must work with the team. Long range coordination is essential. That's the way we solved the atomic problem and that's the way we'll have to solve the cancer problem.

The problem, itself, is fundamentally different, however. In the atomic problem, we were dealing with atoms or units of matter. Much was already known about the atom before the atomic energy project was started. In the cancer problem, we are dealing with human cells, the units of life. We actually know very little about the complex internal chemistry and behavior of the human cell. We, of course, recognize the fact that the cell is the basic unit of life and that life, as we know it, exists only in the cell. We know that bacteria are single cell plants and that protozoa are single cell animals; and we also know that each and every one of us began our existence as single cells. The thing that we don't know is what unknown wisdom in our bodies slowly separates our multiplying cells into various groups; each group with a specific task to perform and each group structurally and chemically different, yet all closely organized as in any well organized community. Neither do we know what makes a certain group of cells run amuck. These are the cancer cells. And Dr. R. R. Spencer of our National Cancer Institute calls them gangster cells. He compares them to human gangsters, running wild in our communities as parasites, crowding out, destroying, and contributing nothing. He even goes further to show that these gangster cells thrive best when environmental conditions are not good.

Cancer is a unique disease. It's not contagious. It's hard to convince people of this fact. People are continuously calling their doctors and asking if they can catch the disease from the patient in their home. Laboratory workers work with cancer constantly and there has been no case recorded of anyone "catching" the disease. In fact, there have been several instances where research workers have deliberately placed cancer cells under their own skin without developing cancer. We have every reason to believe that cancer is not due to a specific infectious agent. Clinical experience and particularly experiments with animals have clearly shown that cancers are the result of a transformation of normal body cells into malignant cells. The characteristic biologic behavior of cancer tissue is therefore due to these permanently altered cells. These cells multiply faster than normal cells and they have the power of invading and destroying normal tissue, thus causing death. If we are to win the battle against this disease, we must determine why cancer cells differ from normal cells and what

causes the transformation of normal cells into cancer cells. We know the structure of the cancer cells, but we are only beginning to learn some of the many causes of their formation. We know of no other disease that can be caused in so many ways. That fact alone makes this an attractive subject to the many scientists who are devoting their lives to a search for the ultimate answer. Normal cells are under control. Cancer cells are unlimited and uncontrolled. We must know what starts the cells which cause the tumor to grow. We have known for many years that the ovum, when fertilized, grows under certain conditions; but no one has ever demonstrated just why it grows. The same can be said for cancer. If nothing else, research has shown over and over that cancer is not a single disease, but a group of diseases. Each type of cancer is derived from a certain type of normal cell and to a certain extent takes on the characteristics of that particular cell.

Experimental research has shown that the different types of cancer are caused by many diversified factors. These factors can be divided into two large groups, the external and the internal factors.

There are numerous examples of external causative factors. Since the time of Madame Curie and Wilhelm Roentgen it has been recognized that excessive exposure to radium, radioactive material or excessive exposure to X-ray, over a period of years, is likely to produce skin cancer or leukemia. In industry, this was first demonstrated among the girls who were employed in painting the luminous dials on watches. This then became an occupational disease.

Another example is seen among sailors, farmers, sheep herders in Australia and, in fact, anyone who has had excessive exposure to strong sunlight, heat and dust. There is a high prevalence of skin cancer in such individuals. These cancers occur on the exposed surfaces—the hands, face and neck. This fact explains why the death rate from skin cancer in Oklahoma, Texas and Arizona is twice as high as it is in New England.

Still another example is the cancer of the urinary bladder found in factory workers engaged in the manufacture of aniline dyes.

It has long been recognized that there is a high prevalence of skin cancers in chimney sweeps and in employees handling coal tar.

These have all been examples of occupational cancers. They are all caused by known external factors and these can be prevented and controlled by the use of proper safeguards. Much educational and safety work has been done in this field. To illustrate this point, it may be stated that for over twenty years it has been a fixed rule in the DuPont aniline dye factory that the workers have periodic cystoscopic examination of their bladders to detect the first signs of urinary cancer.

While the research is being carried on to investigate these external causative factors, a very large number of cancer producing chemicals have been synthesized. Certain coal tars have been found to contain a pure and powerful cancer producing chemical, such as 3:4 benzypyrene. Although a large number of such agents has been discovered there is no evidence that a definite chemical structure is necessary for carcinogenetic activity. These chemicals vary from

simple acids and alkalis: (HCl, NaOH), metal salts ($ZnCl_2$, $ZnSO_4$), radioactive compounds (thorotrast), sugars (glucose), to complicated dyes (dimethylaminoazobenzene), hydrocarbons (3:4 benzypyrene, 1:2:5:6 dibenzanthracene, methylcholanthrene, estrogens (complicated sterols), and viruses (heavy proteins). Many workers are, at present, studying the manner whereby these chemicals produce malignant cells.

There must be many additional external factors. Investigation of these factors must necessarily be carried out along clinical and experimental lines. Since the cancer specialist must, of necessity, devote his ceaseless effort to diagnosing and treating the large number of patients, it seems only logical that investigators will have to be trained to study the environmental conditions and the mode of living in the precancerous histories of cancer patients.

The laboratory worker has numerous opportunities to work in almost virgin fields, in checking these external causes. Dr. Voegtlin has suggested the possibility of carrying out studies on animals to show the possible relation of atmospheric dust and tobacco smoking to cancer of the lung, and of the possible relation of abnormalities in diet to stomach cancer. This work may lead to the prevention and control of cancers of the lung and stomach, two of our greatest killers, much in the same way as studies of occupational factors have furnished practical preventive measures.

The literature is filled with experiments showing evidence that there are many internal factors which produce cancer. There is fairly conclusive evidence, in animals, that abnormalities of the sex hormones are definitely linked up with cancers of the breast and uterus, as well as the glands of internal secretion. This field is being actively investigated at present. Estrogenic substances have been shown to produce breast cancer in certain strains of male, as well as female, mice. Fortunately, this has not been confirmed in humans for it is certainly true that in recent years, it has become fashionable to give massive doses of these ovarian hormones to control menopausal symptoms and regulate the menstrual cycle. Since estrone is only one of an important group of chemicals, known as steroids, which appear in the animal body, there is much need to study the effects of abnormal steroid metabolism in humans as well as in the laboratory animal.

Of course, it is very difficult to correlate and apply our laboratory findings to cancer in the human animal. In the laboratory, we study inbred strains of animals where the hereditary factors can be controlled. Naturally, since the human race is not inbred, we have no control over this great hereditary factor. Due to the unceasing work of such laboratory workers as Maude Slye it has been possible to develop strains of mice with very high or very low incidence of cancer of the breast, lung or liver. Although it cannot be proved, it is felt that the hereditary constitution must play a definite, although perhaps a minor role in human cancer.

The major part of our research, at present, is and should be devoted to the study of the biology of cancer cells. As stated before, we know comparatively little about even normal cells, but we are making progress by using improved

technical methods. We recognize the fact that the principal parts of the cells are the nucleus and the surrounding cytoplasm. In the past, it has been customary to explain the behavior of cancer cells on a supposed abnormality of the nucleus, involving the genes or minute components of chromosomes. This hypothesis has been discarded and we are now considering the possibility that the change in cancer cells may be due to a change in the specific cell protein.

All have heard of, and many are familiar with, the discovery of radioactive and non-radioactive isotopes of the chemical elements. This discovery has given us an entirely new approach to the study of the metabolism of cancer cells and its relation to the metabolism of the body as a whole. Much work is being done through incorporating these isotopes into the molecular structure of natural organic compounds (amino acids, sugars, etc.). This makes it possible to trace these compounds and their end products in their course through the body. The modern physicist with his cyclotron has thus made a great contribution to cancer research. At the present time, they are doing a lot of work with carbon 13 at Antioch College. Similar research is being carried out in other Ohio colleges; and within the past week a large grant was given to Western Reserve Medical School to carry out clinical research along similar lines.

Some of the workers are studying tissue enzymes. Others have shown that the high fermentation of certain sugars by cancerous tissue plays a role in the destructive action of cancer cells on the surrounding normal cells. Still others have shown that restriction of certain amino acids in the diet inhibits the growth of breast cancer in mice without apparently interfering with the general health of the test animal.

It can be seen, from these studies, that we are only beginning to use the isotopes; and there is still a vast, unexplored field which may contain the answer to cancer control.

Since it is necessary to recognize cancer early in order to cure it before it spreads, much investigation is being carried out in the hope of finding some specific and sensitive test. To date, no such test has been found. Tests based on the activity of enzymes in the blood serum have yielded good results only when the cancer is advanced and the diagnosis can be made by other means.

As is evident, much basic information has already been obtained; but our research must go on and be greatly expanded. Research on medical problems in the fields of infectious and metabolic diseases has many times given us findings which were of immediate benefit to the sick patient. A good example of this is the widespread use of such bacteriostatic drugs as penicillin, which came directly from the laboratory into clinical use. We are faced with the realization that this is not true in cancer research. All of the research, to date, has yielded comparatively little which can immediately benefit the patient suffering from cancer. It is true that there is considerable clinical work going on at the present time, using male sex hormones in the treatment of cancer of the breast, and using female sex hormones in treatment of cancer of the prostate gland. It is too early for us to become over enthusiastic about the apparent excellent clinical results from this type of treatment. Some startling new discovery may come suddenly and perhaps from an unexpected source. Until that time comes, we

must continue to improve the tried and true weapons—early surgery, radium and X-ray therapy.

These two methods of treatment have been constantly improved. Sixty years ago, cancer of the breast was considered to be invariably fatal. With our present treatment, 60% of these cases can expect a cure. In 1900, cancer of the stomach was regarded as hopeless. It is no longer a curiosity to see patients surviving at least five years after removal of the stomach. Fifteen years ago, patients with cancer of the lung, lower esophagus, upper stomach and pancreas were considered as hopeless merely because of the location of the growth. Surgical technique has been developed in many institutions whereby these tumors can be completely removed, allowing the patient to survive one or more years in comparative comfort. Because of our improvements in supportive treatment, many patients previously thought to be in the terminal stage have been given relief and a considerable extension of survival. As an example of this, citation may be made of patients with advanced cancer of the prostate. Because such cancers metastasize to the bone early, these patients have previously undergone a long period of pain and suffering. It has been found that surgical castration, in such individuals, although giving no permanent cure often stops all painful symptoms.

Aside from early surgery, our chief weapons, at present, are radium and X-ray used independently and in conjunction with surgery.

The Sunday supplements have recently offered hope in the form of radioactive medication. Reference is made, specifically, to such methods as the use of radioactive iodine in thyroid cancer and the use of radioactive phosphorus in the treatment of leukemia and bone tumors. The clinical evidence at hand does not warrant this unbounded enthusiasm. Perhaps in the future this work may provide a new weapon; but the majority of competent men in this field feel that such treatment is, today, not only extremely hazardous but that it is not nearly so efficient as local radiation.

Radium is chiefly used in the form of tubes or needles. These are placed in direct contact with the tumor. Another very satisfactory and much cheaper method is the use of radium emanation enclosed in a small gold capsule. These seeds contain radon. And over a short period of time their effect is just as good as when radium itself is used.

The most common method of radiation is by the use of deep X-rays. Four types of rays are in general use: (1) low voltage rays, generated in intensities up to 100 kilovolts; (2) moderate or medium voltage rays, generated in intensities up to 150 kilovolts; (3) high voltage rays, generated up to about 220 kilovolts; and (4) supervoltage rays, generated in intensities from 400 to more than 1000 kilovolts.

Because of the highly developed science of atomic physics, both the quality and the quantity of any given beam of X-ray can be precisely measured. Both physical and electrical techniques have been developed sufficiently to provide the roentgenologist with a safe and reliable apparatus which will provide him with whatever dose of rays the clinical indications call for.

Although it must be admitted that radiation therapy is still on an empirical

basis, a great deal is known about the biological basis for such treatment. One of the most useful and important laws, established on this experimental background, is the so-called law of specific sensitivity. Each type of cell composing the human body has a sensitiveness to radiant energy which is the specific property of that cell and which differs from the sensitiveness of other cells. For that reason, some cells react to low voltage rays and are destroyed by high voltage rays. All normal cells have been so classified. In the human, lymphoid cells are the most sensitive and nerve cells are the least sensitive. These are the two extremes. Cancer cells, as a whole, have the same range of sensitiveness as the normal tissue cells from which they are derived. This explains why some tumors 'melt away' rapidly with radiation treatment and others are incurable.

Since the discovery of X-rays it has been known that all doses of such rays produce an injury, depending upon the magnitude of the dose absorbed. The main effect of such irradiation is considered to be the direct destruction of the nucleus of individual cells. There is a secondary effect upon the blood vessels which supply the tissues affected. Both of these effects produce inflammatory changes ending with the formation of scar tissue.

It is possible to overdose, causing secondary and harmful inflammation which nullifies the primary curative effect. Certain parts of the body do not tolerate X-rays as well as other parts. For example, the salivary glands are extremely radiosensitive. This is also true of the upper abdomen.

There is always an X-ray reaction after the administration of even moderate doses. The severity of this reaction depends upon the part of the body radiated and the intensity of the dose. The mildest reaction is a sensation of lassitude. There are sometimes, also, more disagreeable symptoms, such as loss of appetite, nausea, vomiting, headache and prostration. These symptoms usually last only a few hours and every effort is made to keep them at a minimum Every attempt is made to inflict a maximal damage to the tumor with as little effect on the normal tissue as possible. The simplest way to do this is to divide the dose. This is done in many different ways, the most popular being the protracted-fractional system.

I hope that enough of the background of X-ray treatment has been given to show that the X-ray machine is, at most, only the tool of the physician who operates it. X-ray treatment without surgery is only warranted on rare occasions. There are sometimes definite contra-indications to the use of X-ray treatment. When the expert specialist plans his treatment of the cancer patient, he must ask himself, "Can I, if I am fortunate, cure this patient?" If the answer is yes, no effort should be spared to administer sufficient treatment to cure the patient even at the expense of some bodily injury. Of course, he must keep in mind the specific radiosensitiveness of the tumor as well as the reactivity of the patient, for no physician wishes to kill both the tumor and the patient who has it. Where the question is not one of cure, but of palliation the roentgenologist must decide not how much, but how little treatment will give the best results.

In conclusion, it should be re-emphasized that cancer is now a leading medical problem. We must use every method at our disposal to stop this great killer.

Until some better method of treatment is discovered, we must insist on education to encourage earlier diagnosis, early radical surgery, and improved use of radiation techniques.

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